

Preliminary Report: Impact of the Ultra Music Festival on the University of Miami Experimental Hatchery and Virginia Key Sound Scape

The present report summarizes preliminary findings of the impact of Ultra Music Festival on fish at the University of Miami's Experimental Hatchery (UMEH) and the surrounding underwater soundscape. The work discussed herein has been conducted by Dr. Maria Cartolano, Dr. Rachael Heuer, Dr. Christina Pasparakis, Dr. Igal Berenshtein, Mitchel Rider, Stephen Cain and Professor Neil Hammerschlag under supervision of Professors Martin Grosell, Claire Paris and Danielle McDonald.

We anticipate submission of a final report by May 3rd at which time the University of Miami's Rosenstiel School of Marine and Atmospheric Science will circulate a press release summarizing the outcomes of the present study.

Study overview

To assess the possible impact of the recent Ultra Music Festival, sound recordings were collected in air at the University of Miami's Experimental Hatchery (UMEH), in water of tanks housing Gulf toadfish (*Opsanus beta*) at UMEH, in water near the shoreline in Bear Cut at an approximate depth of 3 meters, and in water in Lamar Lake at Virginia Key Beach North Point Park (Figure 1). In addition, blood samples were collected from Gulf toadfish to assess stress levels as indicated by the stress hormone cortisol. Sound and blood samples were collected during undisturbed periods prior to Ultra and during the event.

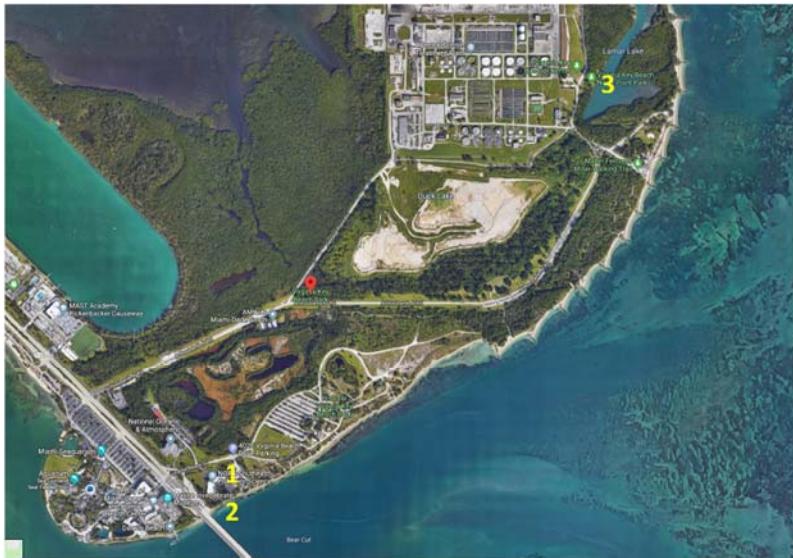


Fig. 1. Virginia Key and sample sites. 1: Site of toadfish sampling and in-tank underwater recordings at UMEH, and sites of soundscape underwater recordings in 2, Bear Cut and 3, Lamar lake.

Findings

Sound recordings in air at the UMEH property rarely exceeded 80 dB during the event. However, despite being well within the permitted limits, the noise pollution caused by the Ultra Music Festival led to significant elevations of noise in tanks at the UMEH (average increase of 10 dB) and toadfish housed in these tanks experienced a clear, and statistically significant, stress response. Baseline blood samples collected from toadfish at night on March 7th, prior to any Ultra set up, and March 25th, prior to sound checks, confirmed that these fish were unstressed as average blood cortisol concentrations were ~ 28 ng/ml. In contrast, samples collected at night on March 29th during Ultra Music Festival, revealed substantially elevated average cortisol concentrations of 121 ng/ml, a 4 to 5-fold increase from baseline values (Table 1).

Underwater sound recordings in Lamar Lake and in Bear Cut (see Fig. 1) are still being analyzed.

Implications

The stress response is complex. In fish, to see an elevation in cortisol, the brain needs to perceive a stressor and secrete a hormone (called CRF). This hormone tells the pituitary gland to secrete a second hormone (called ACTH). This second hormone then tells the kidney interrenal cells (analogous to the adrenal gland in humans) to start production and secretion of cortisol. So, a multistep process occurs prior to an elevation in blood cortisol. Therefore, there are several points of regulation along this stress axis that need to be affected to see a significant increase in blood cortisol and the reactions of fish at each of these points are highly variable. For these reasons, variation in the cortisol response is normal and seeing a statistically significant elevation in cortisol in a group of toadfish in response to noise pollution illustrates significant stress.

The relative elevation (or fold increase) in cortisol in response to the Ultra Music Festival is less than what would be experienced by toadfish exposed to laboratory crowding (Table 1). Being in crowded conditions is a major social stressor for toadfish because of their aggressive nature and because they usually live individually and defend large territories in the wild. However, the relative elevation in cortisol in response to Ultra is higher than what toadfish would experience when being chased by a simulated predator. In comparison to other acoustic stressors, the relative elevation in cortisol in response to Ultra is greater than what toadfish experience in response to boat noises (at slightly higher sound levels than detected from Ultra; Table 1). Additionally, the relative elevation in cortisol in response to Ultra is comparable, but at the high end of the range, to what toadfish would experience upon hearing a predator (Table 1). We conclude that in response to the elevated noise due to first day of Ultra Music Festival, toadfish experienced a level of stress that is higher than what would be experienced when being chased by a simulated predator or when hearing a predator.

Table 1: Resting and post-stress plasma cortisol levels measured in Gulf toadfish.

| Toadfish Stressor | Resting ng·mL ⁻¹ | Post-stress ng·mL ⁻¹ | Fold Increase | Max Sound Level (dB re 1 µPa) |
|-----------------------------|-----------------------------|---------------------------------|-----------------------|-------------------------------|
| Laboratory crowding | 50 | 500 | 10-fold ¹ | n/a |
| Ultra Music Festival | 25, 31 | 121 | 4-5-fold | 120 |
| Dolphin pop sounds | 5 | 20 | 4-fold ² | 137 |
| Simulated predator chase | 75 | 200 | 2.6-fold ³ | n/a |
| Dolphin echolocation sounds | 13 | 8 | 0-fold ⁴ | 137 |
| Boat sounds | 13 | 8 | 0-fold ⁴ | 137 |

¹McDonald et al., 2009 J. Exp. Biol. 212: 704-721

²Remage-Healey et al., 2006 J Exp Biol 209: 4444-4451

³Cartolano MC, Alloy MM, McDonald MD, *unpublished*

⁴Cartolano MC, Paris CB, McDonald MD, *unpublished*

Elevations in cortisol may go on to have physiological effects. Cortisol's main role on a short-term basis is to improve survival of an organism to a stressor. One way cortisol does this is by increasing the amount of sugar in the blood so a fish can fuel escape from a predator. Cortisol also turns off physiological processes unnecessary for acute survival, such as digestion, reproduction, natural social behaviors, and communication, and these responses can affect long-term survival and reproduction. On

a long-term basis, an elevation in stress and cortisol can have detrimental effects, as seen in humans. It can cause reduced growth, muscle wasting, and deterioration. It can also impair the immune system, leading to disease susceptibility and an overall disruption in health and wellness. For wild animals in particular, it can cause long-term decreases in reproduction that can lead to decreases in population size. Therefore, while toadfish experienced a significant stress response to the first day of Ultra Music Festival (a short-term exposure), we cannot conclude if this would translate to long-term elevations in cortisol and these long-term effects.